POINTING AT SMALLER FOOD AMOUNTS IN AN ANALOGUE OF BOYSEN AND BERNTSON'S (1995) PROCEDURE

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Boysen and Berntson (1995) showed that apes could not learn to point to a small amount of candy in order to get a larger amount when pointing to the larger amount was reinforced by receipt of the alternate, smaller amount. They explained this result as an unlearned predisposition to reach for higher value foods that overrides the effects of reinforcement. This report tests their thesis. In the first condition, 3 monkeys chose between one raisin held in one hand by the experimenter and four raisins held in the other hand. If a monkey pointed at four raisins, it received one. If it pointed at one, it received four. Over ten 20-trial sessions, no monkey learned to point at the one-raisin alternative, a result similar to that of Boysen and Berntson. In the second condition, pointing at one raisin still produced four; however, pointing at four raisins now produced no reinforcement. In five 20-trial sessions, all monkeys learned to point at one raisin in order to get four. This finding demonstrates that at least in monkeys there is no predisposition to reach for higher value foods that cannot be readily overridden by reinforcement contingencies, and casts doubt on Boysen and Berntson's claim to have demonstrated such a process in apes.

Key words: choice, maximizing, differential reinforcement, monkeys

In the first condition of an experiment by Boysen and Berntson (1995; also see Boysen, Berntson, Hannan, & Cacioppa, 1996), each of 2 chimpanzees (the selectors) viewed two arrays of candy that differed in size. If a selector pointed at the larger array, it was given the smaller array as its reinforcer, and the larger array was given to a 2nd chimpanzee (the observer) present in the room. Boysen and Berntson found that in eight 12-trial sessions, neither ape learned when it was the selector to point to the smaller array of candy in order to receive the larger array. In the second condition of their experiment, 1 ape no longer chose by pointing at a candy array. Instead, the number of candies in each array was written as a numeral on a card and the cards were shown to the selector ape. Now the ape learned to point to the smaller value numeral so that it, rather than the observer ape, got the larger amount of candy.

Boysen and Berntson (1995) explained the results of these two conditions in terms of the opposed action of two processes: a perceptual process that hindered mastery of this task and a cognitive process that aided task mastery. The perceptual process was posited as an unlearned predisposition to reach for the higher value of two visible food alternatives. The primacy of this predisposition was reflected in the selector apes' failure to learn to point to the lower value food alternative in the first condition of their experiment. The cognitive process, defined as learning the response–reinforcer optimizing contingency of pointing to the small array in order to get the large-array reinforcer, was thought to be operative in the first condition of the experiment; however, this learned relation was overridden by the more powerful unlearned, perceptual predisposition to point at higher value food sources. As evidence for this claim, Boysen and Berntson noted the rapidity with which the selector ape learned in the second condition to point to the smaller of two numbers written on cards when they served as the discriminative stimuli. In their view, the removal of the perceptual predisposition in the second condition by using numerals rather than food arrays enabled the previously learned association between pointing to the smaller food array and receiving the larger reinforcer to emerge.

The present report hypothesizes that Boy-

sen and Berntson's (1995) failure to demonstrate learning in the first condition of their experiment was due not to unlearned perceptual predispositions but to a training procedure that was inadequate to overcome an overlearned choice rule: To maximize reinforcement, always reach for the higher value of two alternatives. Although this rule failed to maximize reinforcement in the Boysen and Berntson procedure, the sanction for this failure was not severe: All nonmaximizing choices were continuously reinforced by the delivery of a candy reinforcer.

We believe that if the differential outcomes of each choice had been made more discriminable in the Boysen and Berntson (1995) study by providing reinforcement only for selection of the small candy alternative, their apes would have maximized in choice even though doing so violated an overlearned response rule. To test this thesis, we created a generalized replication of their procedure with two choice conditions. In the first, monkeys chose between one and four raisins and received as a reinforcer the alternative not chosen. This condition was intended to mimic the relevant features of Boysen and Berntson's first condition. In the second condition, monkeys still got the four-raisin alternative when they pointed to the single raisin, but they received no raisins at all when they pointed to the four-raisin array. This single change between conditions was intended to redress what we believe was the cause of the subjects' failure to learn in the first condition of the Boysen and Berntson report: Their procedure reinforced selection of the large candy array by delivering a candy reinforcer. If our thesis is correct, monkeys should have failed to optimize their choices in our first condition but succeeded in our second.

METHOD

Subjects

One adult female Japanese monkey (Monkey 6) and 2 adult male Japanese monkeys (Monkeys 11 and 12) that were part of the animal colony at the Primate Research Institute of Kyoto University, Inuyama, Japan, served as subjects. Each monkey was individually housed and given unrestricted access to chow and water throughout the experiment.

Apparatus

Each subject's home cage (76 cm deep, 86 cm high, and 90 cm wide) served as the experimental space. The space between successive bars in the front of the cage was 4 cm, a space adequate for the monkey to reach out without apparent difficulty.

Procedure

In the first condition, the experimenter sat on a small stool approximately 1 m from the front of a subject's cage. During each trial, the experimenter held in one hand, palm upward, a single raisin and in the other, four raisins. He displayed the two food alternatives for approximately 5 s and then moved his hands closer to the subject's cage. When the subject reached for one of the food alternatives, that food was immediately dropped and the food in the other hand was given to the monkey. After an approximately 20-s intertrial interval (which was not timed by the experimenter), the next trial began. In the next trial, the positions (left hand or right hand) of the one- and four-raisin alternatives were switched unless the subject had reached for the four-raisin alternative on the prior trial. In the event of such a choice, the assignments of raisins to hands was left unchanged, and the trial was repeated (correction procedure). The session ended after 20 reinforced trials, including those that were repeated choices dictated by the correction procedure. This condition ended after 10 sessions.

In the second condition, the choice procedure was the same except for four changes. First, choice of the four-raisin alternative resulted in the experimenter dropping both hands and denying reinforcement to the monkey. Second, the position assignments of the one- and four-raisin alternatives now changed randomly rather than strictly from trial to trial beginning with the fourth, first, and third sessions of this condition for Monkeys 6, 11, and 12, respectively. Third, each session ended after 20 trials, excluding those that were part of the correction procedure. Finally, the condition ended after five sessions.

Normally the design of this study would have included reversal conditions, returning monkeys to the first and second conditions in subsequent manipulations to see if the results

Table 1

Choices reinforced by four raisins and total number of trials per session not in correction procedure in each condition of the experiment.

Condition	Session	Monkey 6	Monkey 11	Monkey 12
1 (4 vs. 1)	1	5/13	1/7	1/6
	2	0/2	5/9	3/5
	3	0/1	3/6	8/11
	4	1/4	3/7	2/4
	5	1/2	6/11	5/9
	6	4/8	4/9	5/9
	7	2/4	6/12	6/9
	8	2/4	7/14	5/10
	9	3/6	5/11	5/11
	10	2/5	2/5	5/11
2 (4 vs. 0)	1	8/17	10/20	16/20
	2	12/20	9/12	19/20
	3	15/20	16/20	15/20
	4	16/20	5/6	17/20
	5	16/20		17/20

of these conditions were reversible. Unfortunately, this work had to be completed during the senior author's stay in Japan, a time constraint that precluded completing more than the conditions described above.

RESULTS

Table 1 presents the number of selections of the one-raisin alternative in the first and second conditions of the experiment out of all choices that did not occur during the correction procedure. Choice frequencies (of the one raisin) in the first condition did not reach the limit of the 20 reinforced trials that defined a session because all choices, even those in the correction procedure, counted against the session-ending limit of 20 reinforced trials. The same criteria were used in scoring correction and noncorrection trials in the second condition. However, because all correction trials in this condition involved no reinforcement, they did not affect the total number of reinforced trials in a session. Due to an error in following procedure, Sessions 8 and 9 for Monkeys 11 and 12 lasted for 36 trials in the first condition. To ensure comparability to the other data in the table, the results presented for these sessions are based on performances during the first 20 trials. In the second condition, Monkey 6 stopped choosing after Trial 17 in the first session, but completed all 20 trials in the next four ses-

sions. Monkey 11 did not finish Sessions 2 and 4 in the second condition, and was removed from the experiment because of illness after Session 4. All data are based on monkeys' choices prior to stopping responding.

Figure 1 is based on the data of Table 1. This figure presents the percentage of trials in which a monkey selected the one-raisin alternative in the first and second conditions of the experiment. In the first condition, the monkeys failed to learn to point to the single raisin in order to receive a four-raisin reinforcer (by the binomial test, no subject's data varied significantly from chance; $p > .1$ for each subject). However, when exposed to the choice contingencies of the second condition, all monkeys learned to master this task (by the binomial test, each subject's performances were significantly above chance; $p < .002$ for each subject).

The measures in the figure should be viewed as conservative. Had choices in correction been counted in both conditions, the percentage of four-raisin reinforcements received in the first (but not the second) condition would be much lower. This follows from the fact that there were often long runs of one-raisin reinforcers in the first condition (see Table 1); however, in the second condition, the longest such run was four, and that occurred only once for Monkey 11. For virtually all choices after the first session, choices that resulted in no reinforcement occurred, but not during the correction part of the procedure.

DISCUSSION

In choice between one and four raisins, each held in separate hands of the experimenter, monkeys in the first condition of this experiment continued to point to the hand containing four raisins even though this response resulted in a one-raisin reinforcer, and the alternate response of pointing to the hand containing one raisin was reinforced with four raisins. This failure to learn the reinforcement-optimizing choice reproduces in Japanese monkeys a similar finding in chimpanzees in a related procedure by Boysen and Berntson (1995). This failure to learn in their study and ours is important, for it makes plausible our claim that whatever the processes
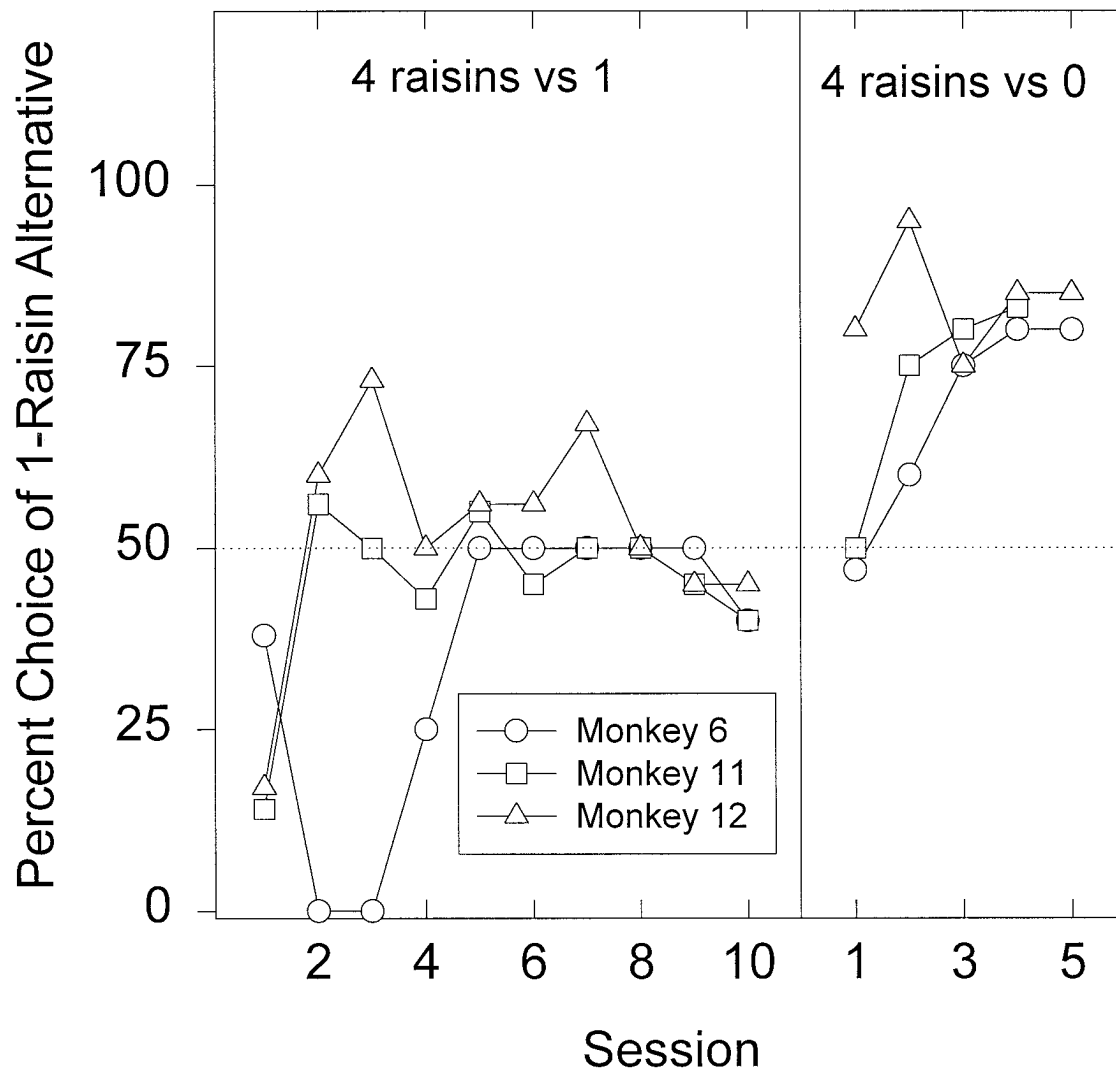
Fig. 1.   Percentage of trials in which the monkey pointed to the one-raisin alternative out of all trials not in correction in the first (left) and second (right) conditions.

that governed choice in each study are, they are likely to be the same in both studies.

If one accepts that the processes of choice are the same in both studies, the results of our second condition become important. In that condition, monkeys learned to point to one raisin in order to get four. This demonstration of learning contradicts Boysen and Berntson's (1995) claim that their data illustrate the operation of a "perceptual-dispositional imperative" that prevents apes from learning to point at the lower valued of two visible food sources. Why did monkeys suc-

ceed in learning what apes could not? We attribute this difference in outcome to a single difference in procedure: In the Boysen and Berntson procedure, pointing to the larger food alternative was reinforced by the food not chosen; in the second condition of our study, it was not.

The failure of differential reinforcement in the first condition of our study and in the Boysen and Berntson (1995) report reminds us of some of the matching-maximizing data that have appeared in this journal. Silberberg and Williams (1974) developed a choice pro-

cedure for pigeons in which the probability of reinforcement changed substantially with the locus of each response. They found that pigeons were quite sensitive to the changes in reinforcement likelihood, and tracked them with their choices so as to maximize. Herrnstein and Heyman (1979), on the other hand, found, in choice between ratio and interval schedules, that pigeons often failed to maximize reinforcement rates. Why did maximizing obtain in one choice situation and not the other? Herrnstein and Loveland (1975) attributed these differences to how sharply reinforcement changes with choice. When those changes are large, clear maximizing results can emerge (e.g., Silberberg & Williams, 1974); however, when choice produces smaller changes in local reinforcement likelihoods (e.g., Herrnstein & Heyman, 1979), choice may fail to maximize (see also Heyman & Tanz, 1995).

Similar language describes the difference between the data in our second condition and the first condition of Boysen and Berntson (1995). In their study, the between-alternative differences in reinforcement were smaller than in ours. As was true for Herrnstein and Heyman (1979), this reduced between-alternative difference in differential reinforcement allowed choice to be controlled by other, nonmaximizing processes.

The next question is: What might this other, nonmaximizing process be? We can preclude its being Boysen and Berntson's (1995) perceptual-dispositional imperative because no imperative is evidenced in our data. However, a weaker, but otherwise sympathetic, reinterpretation of their results is possible. One need only claim their study shows that the ease of learning when pointing serves as the operant depends on the context. This explanation underscores a behavioral predisposition (rather than obligation) to reach for a higher value good and preserves their use of a constitutional factor (an innate link between perception and action) to explain their results.

Although this weaker interpretation is consistent with their data and the results of the present report, it should be noted that the same can be claimed by an explanation of both data sets that is based solely on learning principles. As noted above, the subjects in the Boysen and Bernston (1995) study had a multiyear history of continuous differential reinforcement for reaching for the higher value of two goods. That this degree of overlearning is insensitive to some levels of differential reinforcement seems to us unremarkable given that at its extreme—one alternative reinforced and the other not—choice conforms with the predictions of learning theory.

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